June 13, 1961 H. G. CARLSEN ET AL 2,988,274

CALCULATING MACHINES

Filed Feb. 18, 1958 6 Sheets-Sheet 1

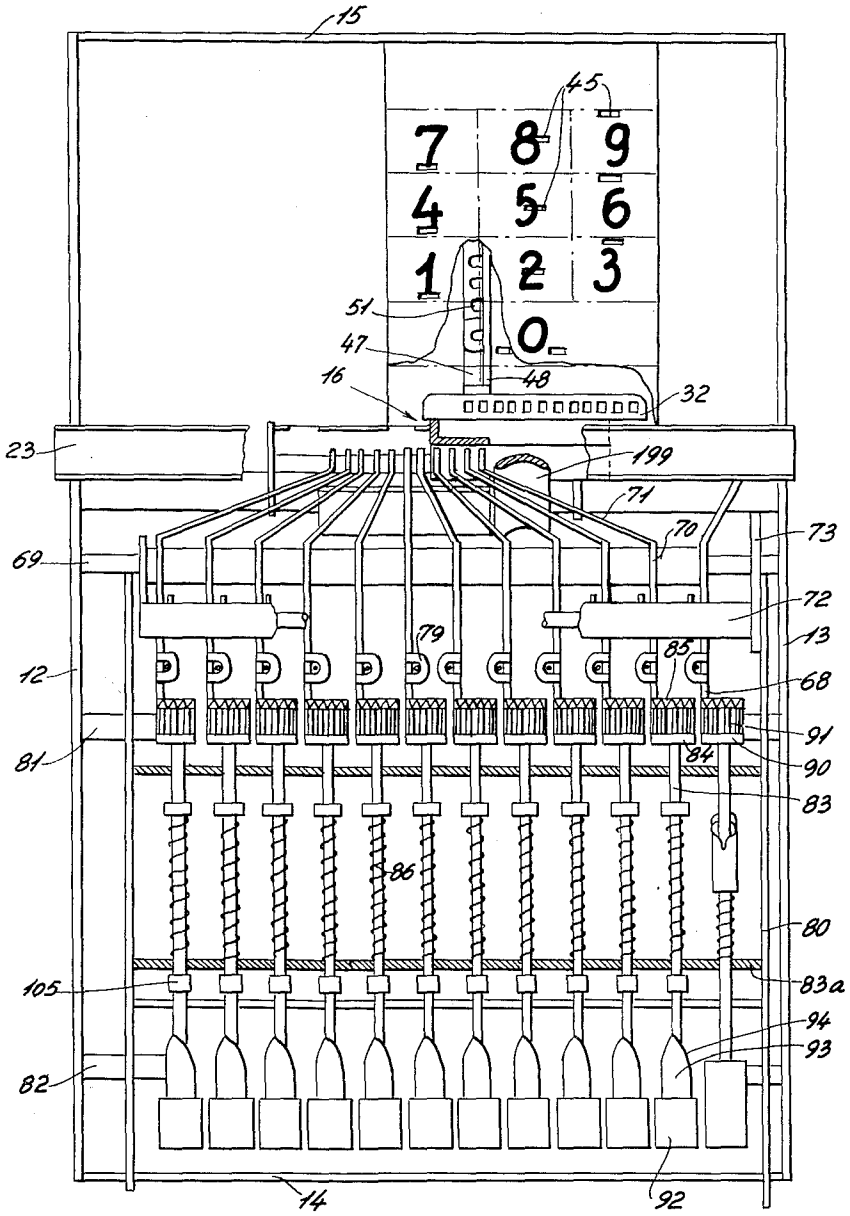

Fig. 1

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CALCULATING MACHINES

Filed Feb. 18, 1958

6 Sheets-Sheet 2

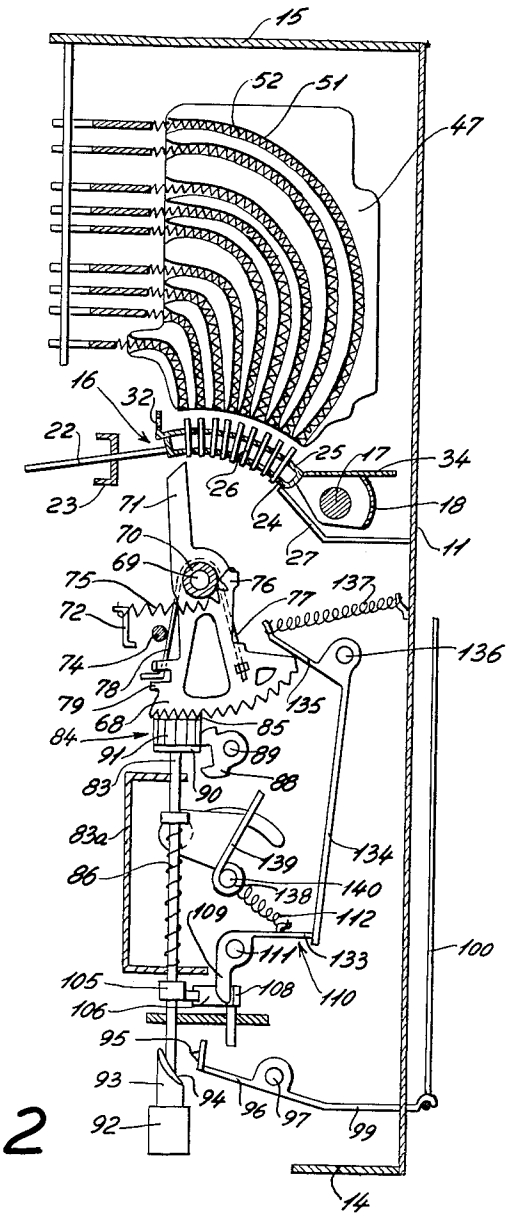

Fig. 2

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H. G. CARLSEN ET AL

Filed Feb. 18, 1958

CALCULATING MACHINES

2,988,274

6 Sheets-Sheet 3

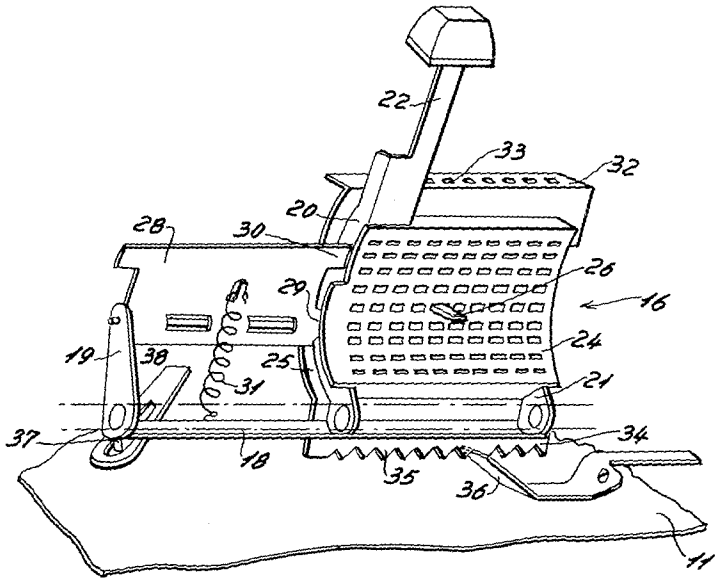

Fig. 3

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June 13, 1961 H. G. CARLSEN ET AL 2,988,274

CALCULATING MACHINES

Filed Feb. 18, 1958

6 Sheets-Sheet 4

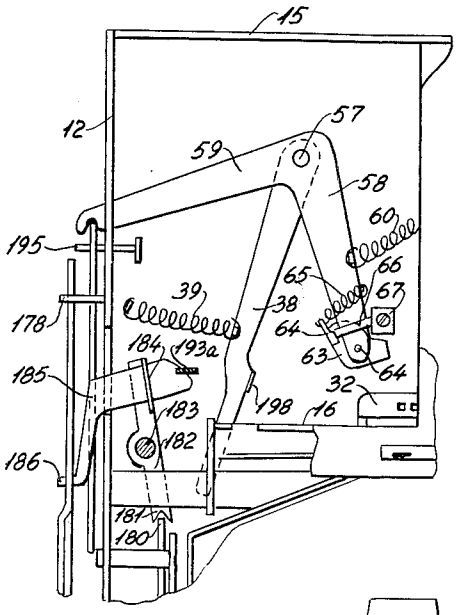

Fig. 7

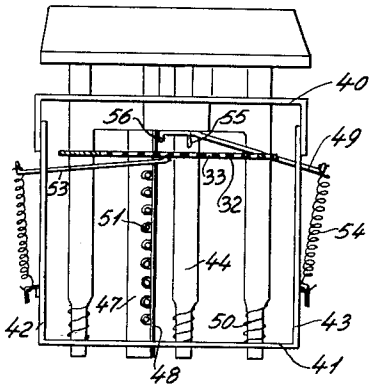

Fig. 4

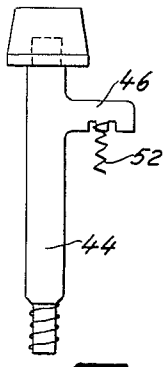

Fig. 5

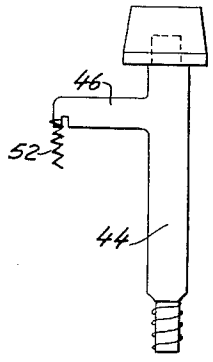

Fig. 6

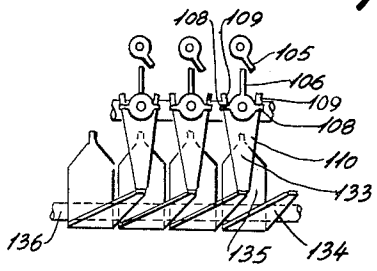

Fig. 8

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June 13, 1961 H. G. CARLSEN ET AL 2,988,274

CALCULATING MACHINES

Filed Feb. 18, 1958 6 Sheets-Sheet 5

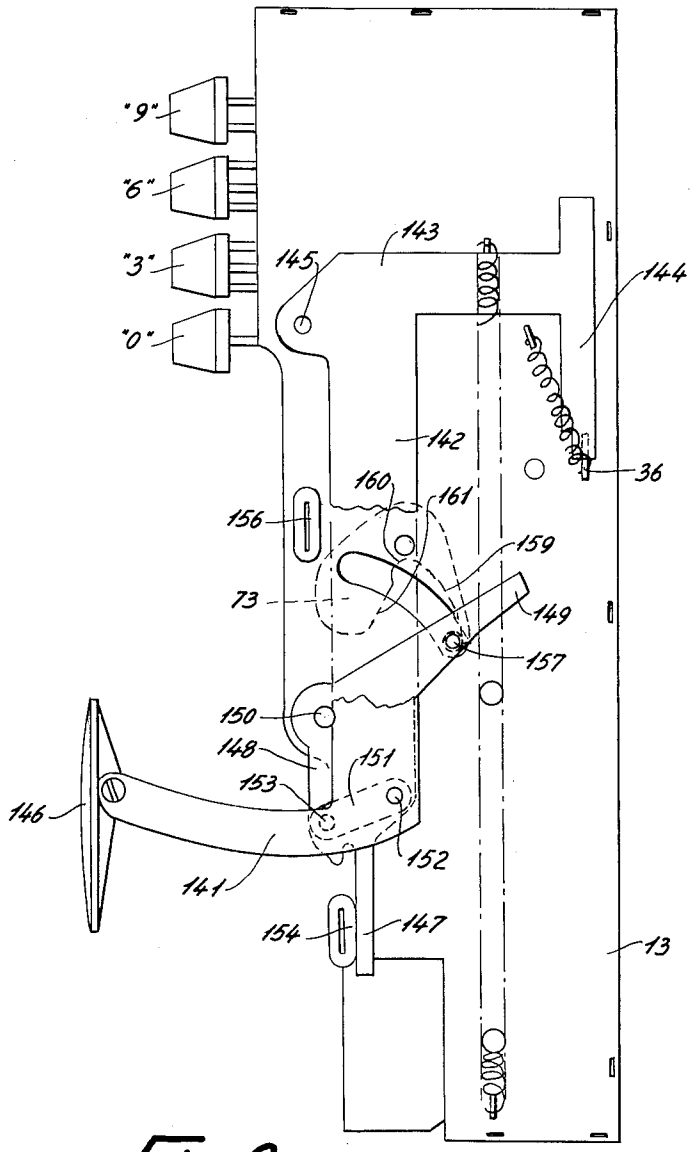

Fig. 9

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CALCULATING MACHINES

Filed Feb. 18, 1958 6 Sheets-Sheet 6

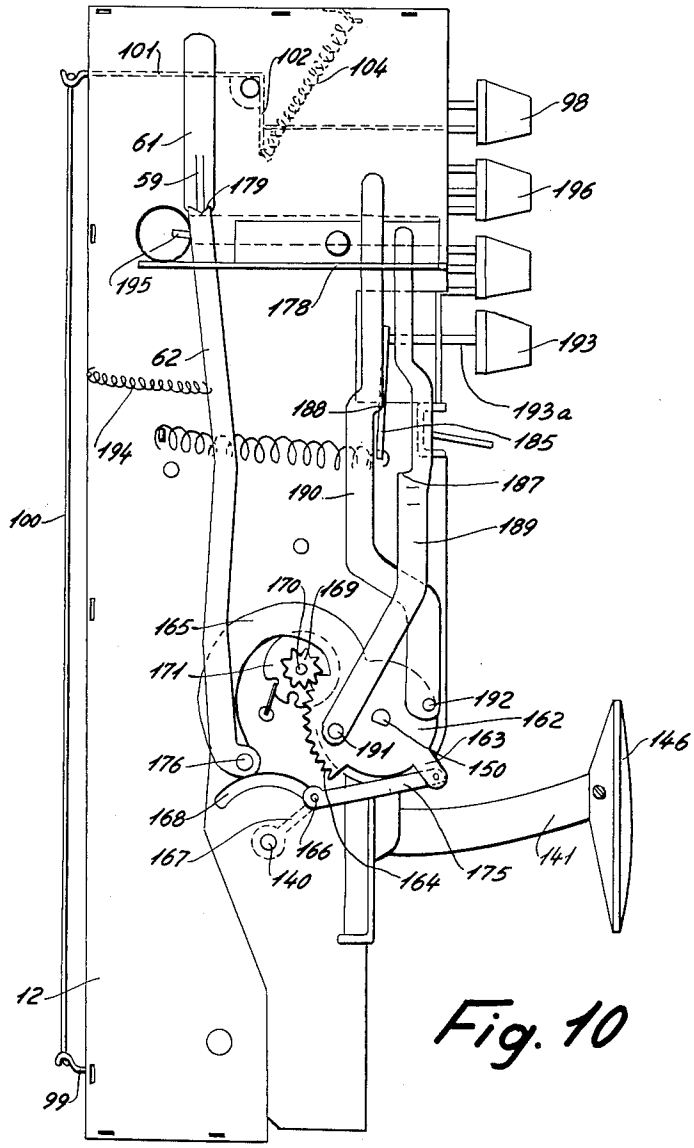

Fig. 10

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United States Patent Office 2,988,274 Patented June 13, 1961

2,938,274

CALCULATING MACHINES

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Filed Feb. 18, 1958, Ser. No. 715,940
Claims priority, application Denmark Mar. 21, 1957
1 Claim. (Cl. 235—73)

This invention relates to a 10-key calculating machine of the type having a carriage in which a plurality of rows of pins—each row corresponding to a digit position or decade of a number to be set up—are slidably mounted, the arrangement being such that the carriage is shifted following each depression of a key so as to present successive rows of pins to the action of the keys to be thereby set in accordance with successive digits of a number to be set up, the machine also comprising a plurality of feeler members adapted, upon operation of an actuating member of the machine, to be moved into engagement with the pins of the carriage and in turn to actuate a product mechanism of the machine in accordance with the feeling motion thus performed.

Calculating machines of this type are known in which the feeler members consist of slidably mounted, rectilinear racks meshing with gear wheels of the product mechanism of the machine. These calculating machines are fully satisfactory for addition and subtraction and may also without difficulty be arranged to perform multiplication and division, but will be relatively slowly operating for the last named arithmetic operations. For machines which are predominantly intended for multiplication and division it is therefore customary to use other principles of construction such as machines having a rotatable drum whereby multiplication and division may be performed at great speed, but, on the other hand, these machines will be relatively slowly operating when used for addition and subtraction.

It is an object of the present invention to devise a calculating machine of the type first referred to which is capable of quick operation both for addition and subtraction and for multiplication and division and is therefore equally well suited for all of these arithmetic operations. It is also an object of the invention to construct a machine of the kind in question which is inexpensive and of light weight.

With these and other objects in view, an important feature of the calculating machine according to the invention resides in the fact that the active surface of the carriage is shaped as a cylindrical surface about the axis of which the feeler members are rotatably mounted.

By thus replacing the rectilinear movement of the feeler members by a rotary movement, it has been found possible to reduce the inertia occurring during the operation of the machine very substantially. The reason for this is that rotatable parts can be guided much more easily than rectilinearly movable parts and can be kept at much smaller dimensions, while the portions thereof which are essential for the guiding function and where a relatively great proportion of the mass must be concentrated is located close to the axis of rotation and therefore does not give rise to very great forces of inertia.

According to a further feature of the invention the carriage consists of a flat curved box having slots for receiving flat pins in radial or substantially radial positions, the said pins being arranged in the usual matrix pattern comprising vertical (in this case arcuate) columns and horizontal rows. In this manner the weight of the carriage may be kept very low which is very important for the speed of operation of the machine considering that the carriage is not only to be shifted by one digit position following each depression of the key, but is also to be moved fully back to its initial position following each cycle of the actuating mechanism so as to be immediately ready to receive a fresh set-up.

In order to avoid all complications and consequent increases of weight in connection with the holding of the pins in withdrawn and advanced position, it is proposed, according to a further feature of the invention, to fill the space between the front and back walls of the carriage with an elastic material that exerts a frictional force on the pins. Preferably this material may be of a character such as also to have a lubricating effect on the pins so as to reduce the wear resulting from the forward and backward sliding movement of the pins in the slots of the front and back wall of the carriage.

To transfer the movements of the keys to the pins of the carriage a stationary channel block may be mounted behind the carriage, said channel block having a curved marginal surface facing the rear side of the carriage and shaped in accordance therewith, a plurality of curved channels extending from positions along said curved marginal surface corresponding to the positions of the pins of one vertical (arcuate) column of pins of the carriage to spaced positions along one upper surface of the channel block, flexible motion transmitting elements being slidably mounted in said channels and having one end thereof in positions to actuate said pins while being adapted at their other end to receive motion on depression of the respective keys of the key assembly. The construction described is a simple means of translating the substantially vertical movements of the key into movements which are substantially radially directed relative to the curved carriage.

Advantageously the feeler members may be formed as rack sectors having feeler arms for co-operating with the pins of the carriage, and preferably the vertical columns of pins of the carriage may be arranged at a smaller spacing than the rack sectors, the arms of the latter being off-set in such a manner as to have their ends located at the same spacing as the said vertical columns of pins. In this manner it has been found possible to obtain a very substantial reduction of the dimensions of the carriage and thereby also of its physical mass which determines the forces of inertia.

To keep the number of transmitting links as low as possible and thereby also to reduce the forces of inertia, each of said rack sectors may be adapted to engage with teeth formed in the cylindrical surface of a drum which is mounted at one end of a shaft carrying a figure drum of the product register at its other end.

Moreover, according to the invention, the whole assembly of shafts and drums may be displaceable during the feeling movement of said rack sectors in a direction such as to disengage said first-mentioned drums from said rack sectors. In this manner, the necessity of using ratchet mechanisms or the like is avoided.

Also, according to the invention, in order to obtain a simple way of change-over between addition or multiplication and subtraction or division, the assembly of said shafts and drums may be laterally displaceable so as to engage said rack sectors with said first-mentioned drums selectively at one or the other side thereof.

The invention will now be described in further detail with reference to the accompanying drawing, in which

FIG. 1 is a diagrammatic plan view of the machine with certain parts broken away and others removed,

FIG. 2 is a side view of the machine as seen from the right hand side in FIG. 1 with one side wall of the main frame of the machine and all of the actuation mechanisms removed and with section through some elements,

FIG. 3 is a perspective view of the carriage of the machine,

FIG. 4 a front view of the key assembly of the machine,

FIGS. 5 and 6 detached views of the "1" and "3" keys,

FIG. 7 a plan view of the so-called forward and reverse conveyor unit of the machine, which is disposed in the upper left hand corner of the main frame as viewed in FIG. 1,

FIG. 8 a front view of the principal parts of the transfer assembly of the machine,

FIG. 9 a side view of the machine from the right hand side in FIG. 1 (with the side wall of the main frame and the actuating mechanism in position), and

FIG. 10 a side view of the machine from the left hand side in FIG. 1.

It is to be understood that the drawings are only diagrammatical and various parts are omitted in the various illustrations to bring out the essential arrangements more clearly. It is to be understood that in practice the machine will be mounted on a base and provided with a cover. These are not illustrated in any of the figures of the drawing.

Frame

The calculating machine illustrated in the drawings has a main frame or chassis comprising a bottom **11**, side walls **12** and **13** and front and rear walls **14** and **15** respectively.

Carriage

A carriage, generally denoted by the reference character **16**, is slidably mounted on a cylindrical bar **17** extending transversely between the side walls **12** and **13** of the main frame. The carriage has the general form of a frame comprising a bottom member **18** and three upstanding members **19**, **20** and **21** constructed with holes fitting around the cylindrical bar **17**. The intermediate upstanding member **20** is formed at its top with a tongue **22** which extends through a longitudinal slit of a channel bar **23** extending between the two side walls **12** and **13**, thereby to provide a further guide for the transverse movement of the carriage.

The upstanding members **20** and **21** are arcuate in shape and between these there is provided a flat cylindrical pin box composed of a curved front plate **24** and a curved rear plate **25** both of these plates having marginal portions extending beyond the upstanding members **20** and **21**.

A multitude of flat pins **26** are slidably mounted in slits of the front and rear plates **24** and **25**, said pins being redaially directed with respect to the curvature of said plates. Each pin is capable of assuming an advanced position and a retracted position and is frictionally engaged by the slits, and preferably additionally by a filling material provided between the plates **24** and **25**, at a force such that when left to itself it will remain in whatever position to which it has been pushed. A suitable filling material may comprise an artificial resin or like material which has at the same time a lubricating effect on the pins to reduce wear between the latter and the slits.

The pins and slits are arranged in a matrix pattern comprising vertical (arcuate) columns and horizontal rows. Each column corresponds to one digit position or decade of a number to be set up in the machine while each row corresponds to a certain digit value, the uppermost row corresponding to the digit value "0" and the lowermost row corresponding to the digit value "8." Thus each column comprises an "0"-pin, a "1"-pin . . . and an "8"-pin. A row of "9"-pins might also have been provided, but to simplify the construction of the carriage and reduce its weight, the "9"-row has been replaced by the upper edge of a stationary member **27** fixed to the bottom **11** of the main frame and referred to in the following description as the "9"-stop.

A plate **28** is rotatably mounted between the upstanding members **19** and **22** and has a lug **29** engaged between the marginal portions of the plates **24** and **25** and another lug **30** extending beyond the edge of the front plate **24**. The upper edge of the plate **28** is in level with the "0"-row of pins, and the plate is biased by a spring **31** which normally keeps the said upper edge flush with the advanced

position of the "0"-pins. From this position the plate may be tilted backwards until the lug **30** strikes the front plate **24** in which position the said upper edge will be flush with the retracted position of the "0"-pins. The plate **28** will be referred to in the following as the "0"-stop.

At its upper edge the rear plate **25** is bent backwards to form a horizontal flange **32**, referred to in the following as arresting flange, which is constructed with a plurality of rectangular holes **33** having a spacing equal to that of the column of pins. At its bottom the rear plate **25** is formed with a downwardly extending skirt **34** constructed at its lower end with teeth **35** engageable by a spring-biased locking pawl **36** which will be referred to below.

A pin **37** extending downwards from the bottom member **18** of the carriage adjacent the end of same where the upstanding member **19** is located, is engaged by an elongated hole of a lever **38** which is biased by a spring **39** and will be referred to in the following as the forward conveyor lever. This forms part of the so-called forward and reverse conveyor unit which will be described below.

Key assembly

Rearwardly of the carriage there is provided a key assembly, the supporting structure of which consists of a box comprising a top plate **40**, a bottom plate **41** and side plates **42** and **43**. A key for each digit value 0–9 is provided above the top plate **10**. The "0"-key extends over the whole width of the key assembly while the other keys are arranged in rows of three. Each key is mounted on a flat stem **44** which is slidably mounted in a slit **45** in the top plate **40** and a similar slit in the bottom plate **41**. In FIG. 2 the keys have been removed to show the arrangement of the slits **45**. It will be seen that two slits **45** have been provided for the "0"-key, meaning that the upper part of the stem of that key is forked, see also FIG. 4. It will also be understood that owing to the different locations of the slits **45**, the operative parts associated with the stems of the various keys will be somewhat different, but the difference is mainly one of dimension and inversion, and it is believed that the said operative parts are adequately illustrated by FIGS. 5 and 6 which represent the "1" and "3" keys respectively.

As will be seen from these figures, each stem **44** is constructed with a lateral arm **46**, and irrespective of the location of the slit **45** in question this must be long enough to overhang both a channel block **47**, **48** and a trigger plate **49** to be mentioned in the following. Besides, it will be noted that the upper edge of the arm **46** forms an abutment limiting the upward movement of the key under the urge of a biasing spring **50**.

Consideration will now be given to the channel block **47**, **48**. This is a flat block which is mounted in a vertical position longitudinally of the key box. It consists of a body portion **47** in which a plurality of channels **51** are engraved, and a cover plate **48** closing the channels **51**. In FIG. 2 the cover plate **48** has been removed to show the channels. These extend along different curved paths from a front edge of the channel block to an upper edge thereof. The said front edge is located directly behind the pin box of the carriage and is shaped as a circular arc co-axial with the pin box. The opening ends of the various channels are located radially behind the respective rows of pins. The other ends of the channels are located directly below the lateral arms **46** of the stems **44** of the respective keys. A flexible push member, e.g. in the form of a tightly wound coil **52** is slidably fitted in each of the channels **51** and has its upper end attached to the respective lateral arm **46**. It will be noted that a channel **51** and coil **52** are provided for each of the "0"–"8"-keys, but not for the "9"-key.

An arresting pawl **53** is pivotably mounted in a slit of the side plate **42** and has its end urged towards the bottom side of the arresting flange **32** of the carriage so as

to be engageable with the right hand edges of the holes 33 of the latter to arrest movement of the carriage under the influence of the forward conveyor lever 38 referred to above.

The trigger plate 49 referred to above is pivotally mounted in slits of the side plate 43 and is biased by means of a spring 54 which urges the upper edge of the trigger plate towards the lateral arms 46. Thus, each of the lateral arms, including that of the "9"-key is capable of depressing the trigger plate. It will be understood that the latter extends over the whole length of the key box and is constructed with oversize holes for the passage of the stems 44 that extend through the region of the trigger plate.

The trigger plate is constructed with a long tooth 55 and a short tooth 56 located above the arresting flange 32 of the carriage in positions such that when the arresting pawl 53 engages the right hand edge of one of the holes 33, as described, the long tooth 55 will be located above the left hand side of another hole 33 while the short tooth 56 will be located above the hole engaged by the arresting pawl 53.

Forward and reverse conveyor unit

This comprises the previously mentioned forward conveyor lever 38 which is rotatably mounted on the bottom 11 of the main frame by means of a pivot 57, and besides, a V-shaped lever 58, 59 which is rotatable about the same pivot 57 and comprises a reverse conveyor lever arm 58 biased by a spring 60 and an operating lever arm 59, the end of which is movable in a horizontal slot 61 of the side wall 12 of the main frame and is engageable by the end of a push rod 62 to be mentioned later (under the heading "actuating mechanism, remote side").

At the end of the reverse conveyor lever arm a pawl 63 is pivoted at 64. The pawl 63 is constructed with a lug 64 engageable with the left hand side of the lever arm 58 under the influence of a biasing spring 65 to bring the pawl into an "active" position. However, the lug 64 also carries a nose 66 which is engageable with a fixed abutment 67 under the influence of the biasing spring 60, and since this is stronger than the spring 65 the pawl 63 will assume a swung back or "inactive" position relative to the lever arm 58 when this is in the position shown.

Rack sector assembly

A plurality of rack sectors 68 are rotatably mounted side by side on a shaft 69 extending transversely between the side walls 12 and 13 of the main frame. Each rack sector has a separate hub 70 and is formed with a feeler arm 71 extending to the region of the pins of the carriage 16. As will be seen, the arms 71 are off-set in such a manner that their free ends are located at a much smaller spacing, corresponding to that of the columns of pins of the carriage, than the rack sectors themselves.

Also rotatably mounted on the shaft 69 is a drive bridge comprising a drive bar 72 extending transversely of the machine over the tops of the rack sectors 68 and mounted on the shaft by means of end pieces, one of which, 73, is formed as a cam engageable by the actuating mechanism, as will be described hereinafter. A second, cylindrical bar 74 extends between the end pieces of the drive bridge in a position directly below the drive bar and parallel thereto. A tensional coil spring 75 connects a lug 76 of each rack sector 68 with the drive bar 72, thus tending to turn the rack sector in the clockwise direction, as viewed in FIG. 2. A U-spring 77, 78 is mounted on one side (the rear side as viewed in FIG. 2) of each rack sector. The lower leg 77 of this spring is rigidly fixed to the rack sector while the upper leg 78—connecting with the lower leg through a curved end portion lying around the hub 70 of the rack sector—is located at some distance above the upper edge of the rack sector and has its end yieldably engaged with a lug 79 of the rack sector so that it is free to yield in a direction towards the body of the rack sector. The U-spring 77, 78 is under a pre-tension tending to spread its legs apart, this spreading being limited by the engagement of the leg 78 with the lug 79. The relative dimensioning of the springs 75 and 77, 78 is such that when the rack assembly is left to itself, the spring 75 of each rack sector will keep the latter in a position in which the leg 78 of its spring 77, 78 abuts the cylindrical bar 74 at a force which is not strong enough to make the leg 78 yield.

Product mechanism

The product mechanism is mounted in a secondary frame 80 which is shiftable transversely of the machine between a right hand position for addition and a left hand position for subtraction. The means for shifting the frame 80 will be described later. The frame 80 is held and guided on two cylindrical rods 81 and 82 extending transversely between the side walls 12 and 13 of the main frame.

A plurality of shafts 83 extending longitudinally of the machine are rotatably and slidably mounted in an upper bridge member 83*a* of the frame 80. At its rearward end each shaft 83 carries a cylindrical drum 84 constructed at its rearward end along its circumference with teeth 85 of a shape such as to be engageable with the teeth of one of the rack sectors 68. Owing to the shiftability of the frame 80, this engagement may be established alternatively at one or the other side of each drum. By means of a biasing spring 86 each shaft 83, when left to itself, will assume a position such as to engage the teeth 85 of the drum 84 with the teeth of the associated rack sector 68.

From this position the shafts 83 may be retraced by means of claws 88 secured to a claw shaft 89 extending transversely of the frame 80. By rotation of the claw shaft through predetermined limited angles by means to be described later, each claw can be caused to engage, from either side, with a head portion 90 formed at the end of the respective drum 84 remote from the teeth 85 thereof, and can likewise be engaged with and disengaged from teeth 91 formed in the portion of each drum 84 between the teeth 85 and the head portion 90.

At the forward end of each shaft 83 there is provided a figure drum 92 having the figures 0, 1, 2 . . . 9 printed on its cylindrical surface, the upright direction of these figures beign longitiudinally of the drum. These drums each correspond to one decade, i.e. units, tens, hundreds, etc. of a number represented in the machine, and it will be understood that in the assembled machine a limited area of each drum is visible through rectangular windows of a cover strip, not shown in the drawing.

Each figure drum 92 has formed integral therewith a sleeve 93 constructed with a cam surface 94 having its "tip," i.e. its point of maximum axial distance from the drum 94 in an angular position, circumferentially of the drum, corresponding to somewhere between figures "0" and "9" on the drum, the cam surface extending from the said "tip" or point along inclined paths along both sides of the sleeve 93 to a point of minimum distance from the drum 92 in line with the figure position "5" on the latter. Each cam surface 94 is engageable by a tooth 95 of a cancellation comb 96 which is pivoted on a shaft 97 extending transversely of the frame 80 and is coupled to a cancellation key 98 in the key section of the machine by means of suitable leverage 99, 100, 101, 102, 103, a biasing spring 104 serving to keep the teeth of the cancellation comb 96 out of engagement with the cam surfaces 94 when the key 98 is not depressed. It will be understood that the cam arrangement is such that when the cam surfaces are engaged by the teeth of the comb 96, the shafts 83 will first yield to the engaging pressure and will thereby be pushed to the left so that the drums 84 are disengaged from the rack sectors 68, and thereafter the shafts and the figure drums 92 thereon will be turned, each figure drum 92 taking the shorter one of the possible ways home to zero position.

Transfer assembly

The outfit for performing transfer from one figure drum, whenever this goes through the zero position, to the figure drum of the next higher order is also mounted in the frame **80**. Each shaft **83** carries a triggering pawl **105** adapted, on passage of the figure drum through the zero position, to strike and thereby tilt a tilting pawl **106** which is rotatably mounted on a transverse member **107** of the frame **80**. The tilting pawl **106** is provided on both sides of its axis of rotation with noses **108** engaged below lugs **109** of a transfer pawl **110** which is rotatably mounted on a shaft **111** extending transversely of the frame and is slightly biased in an anti-clockwise direction, as seen in FIG. 2, by means of a spring **112**. The transfer pawl **110** has a downwardly extending arm **133** which is engaged from below by one arm **134** of a transfer member **134, 135** which is mounted for rotation about a shaft **136** extending transversely of the frame **80** and has another arm **135** located below the rack sector **68** of the next higher order and serving as an abutment to limit movement of said rack sector in the anti-clockwise direction, as seen in FIG. 2. A spring **137** serves to bias the transfer member **134, 135** in the clockwise direction, and a fixed abutment **138** serves to limit its movement in that direction. A restoration cam **139** which extends transversely of the machine above all of the arms **134** is secured to a shaft **140** which is rotatably mounted in the frame **80**.

Actuating mechanism, actuation side

A principal actuation lever **141, 142, 143, 144** is pivotably mounted at **145** on the outer side of the side wall **13** of the main frame and comprises an upstanding stem **141** carrying an actuation key **146**, a horizontal portion **142**, a downwardly extending arm **143** and, at the lower end of the latter, a horizontally extending heel portion **144** which normally engages the locking pawl **36** referred to above "carriage" to keep the latter out of engagement with the locking teeth **35** of the carriage, but already after a slight angular movement of the principal actuation lever permits such engagement to take place.

A secondary actuation lever **147, 148, 149** located between the principal actuation lever and the side wall **13** is secured to a shaft **150** extending transversely of the main frame and is drivably connected with the principal actuation lever by means of a link **151**, the pivotable connections of the latter with the principal and secondary actuation levers being denoted by the reference characters **152** and **153** respectively. Part **147** of the secondary actuation lever is engageable with a fixed abutment **154** under the influence of a return spring **155** acting on the arm **143** of the principal actuation lever, thereby to define the "normal" position of both actuation levers and thereby of the whole actuating mechanism. Part **149** of the secondary actuation lever is engageable with another fixed abutment **156** to define the "bottom" position of the principal actuation lever.

Part **149** of the secondary actuation lever also carries a roller **157** which extends through a curved slot **158** in the side wall **13** of the main frame to engage a generally V-shaped cam surface **159, 160, 161** of the drive cam **73** of the rack sector assembly.

Actuating mechanism, remote side

As will be remembered, the shaft **150** to which the secondary actuation lever is secured extends transversely of the main frame, and on the outer side of the side wall **12** it carries a tertiary actuation lever **162, 163, 164, 165** which serves a multitude of functions and has the general shape of a disc **162** formed with a lug **163**, a rack sector **164** and a long, curved tail **165**. A link **175** connects the lug **163** with a crank **166, 167** secured to the shaft **140** of the restoration cam **139** "transfer assembly" and having its crank pin extending through a

curved slot **168** of the side wall **12**, the link **175***a* having sufficient play to allow for lateral shifting of the secondary frame **80** between its plus and minus positions.

The rack sector **164** meshes with a gear wheel **169** secured to a rotatably mounted shaft **170** which also carries a disc **171** formed with two notches **172** and **173** in its circumferential surface which is engaged by a lug **174** secured to the claw shaft **89** "product mechanism." The lug **174** has a sufficient length longitudinally of the shaft **89** to engage the disc **171** properly in both the "plus" and the "minus" positions of the secondary frame **80**.

The tail **165** circumvents the gear wheel **169**, and to its end the previously mentioned push rod **62** "forward and reverse conveyor unit" extending along the side of the side wall **12** is pivotably attached at **176**. The push rod **62** is guided in an oversize vertical slot of a bracket **178** secured to the side wall **12**. At its free end the push rod is constructed with a V-shaped notch **179** engageable with the operating lever arm **59** of the "forward and reverse conveyor unit."

Plus and minus shifting outfit

The rearward end of a member **180** of the frame **80** (e.g. one side wall thereof) is engaged by a claw **181** formed at the end of a lever **182** which is mounted for rotation about a vertical shaft **183** extending between the bottom **11** of the main frame and the channel bar **23** "carriage." Integrally with the lever **182** there is formed an upstanding stem **184** which may also have its upper end supported on the shaft **183** by means of a suitable lug, not shown. A shifting arm **185** is rotatably mounted in a horizontal slit of the upstanding stem **184** and has a nose **186** which, by shifting of the arm **185**, is alternatively engageable with shoulders **187** and **188** formed on two bars **189** and **190** respectively, which are pivotably connected with the disc **162** at **191** and **192** respectively and have their free ends guided in vertical slits of the bracket **178**. Shifting of the arm **185** is performed by means of a shift key **193**, the stem **193***a* of which treads on the end of the arm **185** remote from the nose **186**. The shift key **193** may advantageously be upwardly biased and be self-locking in its depressed position and self-releasing therefrom in well known manner.

Multiplication outfit

The push rod **62** rests under the influence of a spring **194** on a pivotably mounted arm **195** which is depressable by means of a multiplication key **196** against the action of a spring whereby the push rod **62** gets out of line with the operating lever arm **59** of the "forward and reverse conveyor unit." The multiplication key **196** is preferably self-locking in its depressed position in well-known manner.

Operation

The various phases of the operation of the machine will now be described.

Setting-up of a number in the carriage

Suppose the first digit of a number to be set up is "3." Upon depression of the "3" key, the lateral arm **46** associated with that key causes the "3"-coil **52** to slide forward in its channel **51**, thereby to push the "3"-pin **26** in the first column of such pins of the carriage forward to its advanced position.

Moreover, the lateral arm **46** depresses the trigger plate **49** whereby the long tooth **55** first enters one of the holes **33** of the arresting flange **32** of the carriage adjacent the left-hand side of that hole, and thereafter the short tooth **56** enters another one of the holes **33** to depress the arresting pawl **53** which has hitherto been engaged with the right-hand edge of the last named hole **33**. Consequently, the forward conveyor lever **38** is now permitted to move the carriage slightly to the left until the long tooth **55** strikes the right-hand edge of the hole into

which it has been entered. This movement of the carriage is too small to disturb proper co-operation between the coil **52** and the pin **26**.

When the "3"-key is released, it commences its return stroke under the influence of its biasing spring **50** and also the biasing spring **54** of the trigger plate **49**.. The coil **52** is disengaged from the "3"-pin **26**, leaving the latter in its advanced position, and the short tooth **56** of the trigger plate **49** is disengaged from the arresting pawl **53**, permitting the latter to apply itself, under the influence of its biasing spring, against the bottom face of the arresting flange **32** of the carriage. Somewhat later, the long tooth **55** of the trigger plate **49** is retracted from its hole **33**, thereby permitting the forward conveyor lever **38** to move the carriage further to the left until the arresting pawl **53** catches the right-hand edge of the next following hole **33**. The carriage has now been moved one full step to the left corresponding to the spacing of the holes **33** and consequently also to the spacing of the columns of pins **26**. The first of these columns, in which the "3"-pin has been pushed forward, is now in line with the end of the feeler arm **71** of the "units" rack sector **68**, while the second column of pins **26** is in line with the channel block **47**, **48** of the key assembly.

Supposing the next digit of the number to be set up is 5, the "5"-key is now depressed, whereby the "5"-pin **26** of the second column of pins is pushed forward, and the carriage is moved one further step to the left, leaving the first column of pins **26** in line with the end of the feeler arm **71** of the "tens" rack sector **68**, the second column of pins **26** in line with the end of the feeler arm of the "units" rack sector **68**, and the third column of pins **26** in line with the channel block **47**, **48**.

In this manner, all the digits of the number are set up in successive columns of pins **26** of the carriage. If any of the digits is "9," no pin is pushed forward in the column representing that digit, but depression of the "9"-key serves to move the carriage one step to the left in the same manner as described above.

Operation of carriage by actuating mechanism

At the commencement of the down-stroke of the principal actuation lever **141**, **142**, **143**, **144** the heel **144** permits the locking pawl **36** to engage the locking teeth **35** of the carriage, and this engagement is preserved until shortly before the end of the up-stroke of the principal actuation lever.

During the down-stroke of the principal actuation lever, the push rod **62** connected to the tail **165** of the tertiary actuating lever is pushed in the rearward direction and thereby rotates the lever arm **59** of the "forward and reverse conveyor unit" in the clock-wise direction as seen in FIG. 7, thereby tensioning the spring **60**. Towards the end of the down-stroke of the principal actuation lever the pawl **63** of the reverse conveyor lever arm **58** slides past a lug **198** provided on the forward conveyor lever **38**, the pawl being tilted about its pivot **64** as it strikes the said lug **198**. After the pawl has thus passed by the lug **198**, its spring **65** turns it back to its "active" position in which its lug **64** engages the left-hand side of the lever arm **58** (which position it first assumed when the nose **66** was disengaged from the abutment **67** at the commencement of the movement of the lever arm **58**).

During the up-stroke of the principal actuation lever, the push rod **62** is retracted, thus permitting the reverse conveyor lever **58**, **59** to rotate in the anti-clock-wise direction under the influence of the spring **60**. However, at first no such movement takes place because the pawl **63**, which is in its active position, engages the lug **198** of the forward conveyor lever **38** which is prevented from moving by its engagement with the carriage which is locked by the locking pawl **36**. When the latter is finally disengaged from the locking teeth **35** of the carriage, the reverse conveyor lever **58**, **59** is swiftly rotated by the spring **60**, and by the engagement of the pawl **63** with the lug **198** this movement is also transferred to the lever **38**, so that this is now rotated in the reverse direction to move the carriage to the right, the spring **60** being stronger than the spring **39** and tensioning the latter during the movement here considered. When the nose **66** of the pawl **63** strikes the abutment **67**, the pawl is tilted back to its inactive position and is thereby disengaged from the lug **198**, whereby the forward conveyor lever **38** is permitted, under the influence of the spring **39**, to move a little to the left until the arresting pawl **53** engages the right-hand end of the first hole **33** of the arresting flange **32** of the carriage, whereby the latter is back in its starting position.

During the reverse movement of the carriage a stationary push-back plate **199** will push back all the pins **26** that were pushed forward to the advanced position during the setting-up of the number in the pin assembly of the carriage. Towards the end of the said reverse movement, the push-back plate **199** will strike the "0"-stop **28**, but no harm is done seeing that the "0"-stop is capable of yielding until its lug **30** strikes the front plate **24** of the pin box. From this position, the "0"-stop is tilted back to its normal position by its spring **31** during the final forward movement of the carriage to its starting position.

Operation of rack sector assembly and product mechanism by the actuating mechanism

At the commencement of the down-stroke of the principal actuation lever **141**, **142**, **143**, **144**, the disc **171** is turned through the intermediary of the gear wheel **169** and the rack sector **164** of the tertiary actuation lever **162**, **163**, **164**, **165** in such a manner that the lug **174** on the claw shaft **89**, which has hitherto been engaged in the notch **172** of the disc **171**, is now moved out of the said notch to slide along the circumferential surface of the disc **171**. Hereby the claw shaft **89** is rotated in such a manner that the claws **88** are caused to retract the shafts **83** so as to disengage the drums **84** from the rack sectors **68**. At the same time, the claws **88** engage with the teeth **91** of the drums **84** to lock these drums against rotation.

At the commencement of the down-stroke of the principal actuation lever **141**, **142**, **143**, **144**, the roller **157** carried by the secondary actuation lever **147**, **148**, **149** engages the lower part **159** of the cam surface of the drive cam **73** of the rack sector assembly. The shape of that part **159** of the cam surface is such that in the normal position of the principal actuation lever the bridge **72**, **73**, **74** is kept in a position such that the cylindrical bar **74** urges the rack sectors **68** into contact with the arms **135** of the transfer members **134**, **135** at a force such that the U-springs **77**, **78** are slightly compressed. Now, it will be seen that the part **159** of the cam surface of the drive cam **73** has a shape such that, gradually as the roller passes along that part **159**, the drive bridge **72**, **73**, **74** is permitted to rotate slightly in the clock-wise direction as seen in FIGS. 2 and 9 under the influence of the U-springs **77**, **78** which are thereby relaxed. When the roller **157** arrives at part **160** of the cam surface of the drive cam **73**, the roller positively engages the drive cam to rotate the latter in a clock-wise direction during the continued travel of the roller **157**. The spring **75** of each rack sector causes the same to take part of that movement of the drive bridge until the end of the feeler arm **71** of each rack sector strikes the pin **26** that has been pushed forward in the column of pins in line with the end of the respective feeler arm **71**. In this manner the rack sector of each decade is rotated through an angle corresponding to the digit to be set up in the respective decade of the product mechanism. Where the rigit is 9, the rotation of the rack sector is continued until the end of its feeler arm strikes the station-

ary "9"-stop 27. The feeler arms of all the rack sectors 68 of higher order than the digit of the highest order set up in the column of pins of the carriage will be arrested by the "0"-stop 28. Consequently, these rack sectors will not be rotated, and the same applies to rack sectors co-operating with any columns of pins 26 in which the digit 0 has been set up.

During this rotary movement of the rack sectors 68 these are out of engagement with the drums 84, having been disengaged from the latter by means of the claws 88, as described, during the travel of the roller 157 along the part 159 of the cam surface.

Considering now again the disc 171, this continues to rotate during the down-stroke of the principal actuation lever, and shortly before the end of that stroke the lug 174 temporarily enters the notch 173, and then again jumps up onto the part of the circumferential surface of the disc 171 between the notches 173 and 172. During the temporary engagement of the lug 174 in the notch 173 the claw shaft 89 is temporarily rotated so as to permit the shafts 83 to move somewhat in a direction towards the rack sectors, but this movement is only incidental and has in fact no effect.

However, at the commencement of the up-stroke of the principal actuation lever 141, 142, 143, 144, when the disc 171 is rotated in the opposite direction, the lug 174 again enters the notch 173 and is thereby reversed so that during the continued rotation of the disc 171 the lug 174, when again pushed back so as to slide on the circumferential surface of the disc 171, will rotate the claw shaft 89 in the reverse direction, whereby the claws 88 will push the shafts 83 in a direction towards the rack sectors so as to engage the teeth 85 of the drums 84 with the rack sectors 68, while at the same time disengaging the claws from the teeth 91 of the drums 84.

These functions are complete during the part of the up-stroke of the principal actuation lever when the roller 157 engages the part 161 of the cam surface of the drive cam 73 so that the drive bridge 72, 73, 74 of the rack sector assembly remains in the position to which it was rotated during the down-stroke of the principal actuation lever. When the roller 157 proceeds to the part 160 and subsequently to the part 161 of the said cam surface, the drive bridge 72, 73, 74 is rotated back to its starting position, and thereby each rack sector is rotated, by the engagement of the cylindrical bar 74 with the U-springs 77, 78, through an angle corresponding to the angle through which it was rotated during the down-stroke of the principal actuation lever. This reverse rotary movement of each rack sector is transmitted to the drum 84 in engagement with the rack sector considered and thereby to the figure drum 92 belonging to the rack sector in question. Consequently, each drum 92 is rotated through an angle corresponding to the digit set up in the column of pins 26 that has been moved into alignment with the end of the feeler arm 71 associated with the respective drum 92. In other words, the whole number that was originally set up in the pin assembly of the carriage has now been recorded in the assembly of drums 92, which forms the product register of the machine.

Immediately before the end of the down-stroke of the principal actuation lever, the lug 174 again enters the notch 172 of the disc 171 so that it will again be reversed at the commencement of the next following down-stroke of the principal actuation lever.

Addition

When another number is set up in the pin assembly of the carriage in the manner described, and the principal actuation lever is then depressed, all the operations described will be repeated, whereby the new number will be added to the number already recorded in the product register formed by the drums 92.

Operation of transfer mechanism

It remains, however, to be examined, how transfer takes place from each of the figure drums 92 to the figure drum of the next higher order when the former figure drum passes through its zero-position, thereby recording a total in excess of ten.

It will be understood that during the reverse rotary movement of the rack sectors, the end position of these will be determined by the arms 135 of the transfer members 134, 135 because the rack sectors are urged against these arms by the pressure exerted by the cylindrical bar 74 on the upper legs of the U-springs 77, 78. Now, the normal position of each transfer member 134, 135 is that in which the arm 135 is engaged below the arm 133 of the transfer pawl 110, so this defines the normal zero-position of the rack sectors 68. If, however, during the actuation cycle one of the figure drums 92 has passed through its zero-position, the transfer member 134, 135 co-operating with the rack sector of the next higher order will have been disengaged from the arm 133 of the transfer pawl 110 and thereby will have been tilted backwards under the influence of its spring 137 until the arm 134 has been arrested by the fixed abutment 138. Consequently, the rack sector 68 is permitted to rotate beyond its normal zero-position and will do so under the influence of the U-spring 77, 78 which in the normal zero-position of the rack sector is sufficiently compressed to allow for the required amount of follow-up movement whenever the transfer member 134, 135 permits. This additional follow-up movement corresponds to one step of rotation of the figure drum 92 associated with the rack sector considered so that the only figure recorded by that drum is increased by 1.

Any rack sectors which have thus been permitted to rotate beyond their normal zero-position remain in the position thereby assumed until the rack sectors have been disengaged from the drums 84 at the commencement of the next following down-stroke of the principal actuation lever in the manner described above. Thereafter, the restoration cam 139 which is operated from the tertiary actuation lever 162, 163, 164, 165 by means of the link 175, the crank 166, 167 and the shaft 140 restores any transfer members 134, 135 tilted during the previous actuation cycle to their normal positions with their arms 134 engaged below the arms 133 of the transfer pawls 110. Consequently, the transfer assembly is again ready for operation during the up-stroke of the principal actuation lever, when a new number is being transmitted from the carriage to the product register formed by the drums 92.

Subtraction

When the subtraction or shift key 193 is depressed, which may be done before or after the number has been set up in the assembly of pins 26 of the carriage, the shifting arm 185 is rotated about its line of support in the stem 184, so that its nose 186 is moved upwards in position to engage with the shoulder 187 of the bar 189. During the subsequent down-stroke of the principal actuation lever, after the drums 84 have been disengaged from the rack sectors 68 immediately at the commencement of that stroke, the bar 189, in moving in the rearward direction of the machine, will displace the nose 186 in the same direction, and consequently the stem 184 and the lever 182 are rotated in the clock-wise direction as seen in FIG. 7, whereby the claw 181 moves the frame 80 from its right-hand position to its left-hand position.

The consequence of this shifting of the frame 80 is that when the shafts 83 are again displaced in a direction towards the rack sectors 68 during the up stroke of the principal actuation lever, the drums 84 will be engaged with the rack sectors from the other side so that when the rack sectors are returned to their zero position, the drums 84 and consequently also the figure drums 92 will be rotated in the reverse direction, meaning that subtraction is taking place instead of addition.

Transfer from one figure drum to another will take

place during subtraction in the same manner as during addition, because the trigging pawl **105** will also actuate the tilting pawl **106** when the figure drum rotates through the zero position in the reverse direction, and though the tilting movement of the tilting pawl **106** thereby caused is in the opposite direction, the effect on the transfer pawl **110** and the rest of the transfer assembly is the same, because the tilting pawl has noses **108** on both sides engaged between lugs **109** of the transfer pawl **110**. Moreover, the rear ends of the transfer members **134**, **135** have a width great enough to be engageable by the rack sectors **68** no matter whether the frame **80** on which the transfer assembly is mounted is in the "addition" or in the "subtraction" position.

When the shift key **193** is no longer depressed, the nose **186** will again be shifted downwards into the operating zone of the shoulder **188** of the bar **190**, and consequently during the subsequent down-stroke of the principal actuation lever, after the drums **84** have been disengaged from the rack sectors **68**, the nose **196** will be caught by the shoulder **188** and thereby will be moved in the forward direction of the machine. As a result of this the stem **184** and the lever **182** are rotated in an anti-clock-wise direction, whereby the claw **181** is caused to shift the frame **80** back to its right-hand position so that the machine is now again ready for addition.

Multiplication and division

When the multiplication key **196** is depressed, the end of the arm **195**, on which the push rod **62** rests, is moved downwards, whereby the push rod **62** gets out of line with the operating lever arm **59** of the forward and reverse conveyor unit. Consequently, the said arm **59** is not moved during the following actuation stroke, and this again means that the carriage is not shifted back to its zero position, and as a further consequence of this the pins **26** of the pin assembly of the carriage that are in their advanced position remain in that position so that the number that has been set up in the pin assembly remains recorded therein. Therefore, as long as the multiplication key remains in the depressed position, the same number will be added in the product register in each actuation stroke so that multiplication takes place, the multiplier being represented by the number of strokes of the actuating mechanism.

When the multiplier comprises more than one digit, the carriage should be shifted one step to the left when passing over from one digit of the multiplier to the digit of the next higher order. This may be done simply by depressing the "0"-key.

Similarly, division can be performed by a series of subtractions of a number recorded in the pin assembly of the carriage. When starting the operation of division the divisor should first be set up followed by the highest number of 0's that will leave a quotient higher than unity, and the carriage should then gradually be shifted to the right according to well known principles.

Preferably, special operating members will be provided for shifting the carriage to the left and to the right in the operations of multiplication and division respectively, and means may also be provided for arresting the actuation mechanism when, in performing the operation of division, the number represented in the product register has become smaller than that represented in the pin assembly of the carriage so that shifting of the carriage has to take place. Such addition means may be constructed in accordance with well known principles and do not as such form part of the invention.

In the embodiment shown, it will be noted that in addition to the figure drums **92** representing the units, tens, hundreds etc. a further drum **92** is provided immediately at the right hand side of the frame **80**, which drum serves to count the number of actuation strokes when performing the operations of multiplication and division. This drum forms part of a calculation section of exactly the same kind as the other drums **92**, only the rack sector **68** associated with the counting drum **92** does not co-operate with pins of the carriage, but with a fixed abutment in the "1"-position. Preferably the drum **92** has figures printed thereon both in the forward counting direction (multiplication) and in the reverse counting direction (subtraction).

We claim:

A 10-key calculating machine comprising a key assembly, a carriage of generally curved configuration having a plurality of columns of pins displaceably mounted therein so as to have their ends located substantially on a cylindrical surface, the axis of which extends transversely of the longiudinal direction of the machine, means associated with said key assembly for transmitting setting motion from the keys of the key assembly to the pins of the carriage, means for shifting the carriage along its axis following each depression of a key so as to present successive columns of pins to the action of the keys, a plurality of feeler members mounted for rotation about an axis coinciding with that of said cylindrical surface, said feeler members respectively comprising rack sectors having feeler arms for cooperation with said pins, actuating means for rotating said feeler members into engagement with the pins of the carriage, thereby to set said feeler members in accordance with the settings of the pins, shafts mounted for rotation about axes extending longitudinally of the machine, a cylindrical drum coaxially mounted on one end of each said shaft, teeth formed at the rear end of said drum, a figure drum carried at the other end of each said shaft, each of said rack sectors being adapted to engage with said teeth, said shafts and drums being displaceable during the feeling movement of said rack sectors in a direction to disengage said first-mentioned drum from said rack sectors, the assembly of said shafts and drums being also laterally displaceable, so as to engage said rack sectors with said first-mentioned drums selectively at one or the other side thereof.

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